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Guidelines for evaluation of Canadian Forces indoor firing ranges

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DEFENCE AND CIVIL INSTITUTE OF ENVIRONMENTAL MEDICINE

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GUIDELINES FOR EVALUATION OF CANADIAN FORCES INDOOR FIRING RANGES

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Executive Summary

Indoor Firing Ranges (IFR) within DND are typically used by Canadian Forces (CF) personnel, Cadets, RCMP, and civilian organizations for firing small bore weapons in support of both operational/occupational and recreational requirements. As indoor ranges are an enclosed space, control measures must be in place to ensure that contaminants generated during weapons' firing are kept within acceptable exposure limits. The contaminant of most concern when firing a weapon in an enclosed space is lead. During firing lead from the round is physically chaffed off as the round passes down the barrel and further lead is released as the round strikes the backstop. All of this contributes to the presence of airborne lead and exposure to a contaminant which can cause a major respiratory health concern. Thus, it is important to ensure that lead exposures are kept **As Low As Reasonably Achievable** (ALARA) through the consistent, thorough evaluation of all aspects of an IFR. Assessment of the potential lead exposure, within an IFR, requires an evaluation of the current cleaning procedures, sanitation practices of users, assessment of IFR ventilation, air monitoring of lead concentrations, and monitoring of blood lead levels of personnel when required. Due to the potential health implications it is essential that inspections of IFR be complete. Thus, this guideline has been written with the intention of providing a comprehensive "step by step" methodology for evaluating IFR's within DND. It is intended for use by Preventive Medicine Technician's (PMed Techs) who are aware and comfortable with the principles and practices of Industrial Hygeine: specifically those trained in the use and handling of air sampling pumps; velometers; calibrators; and, the general concepts of conducting an Indoor Firing Range survey. It is also intended as a "general" guideline for users and maintainers as an aid in understanding the process and the decision-making (consultation with PMed Techs). This guideline provides an inspection framework from a practical point of view with interactive theory and practical applications aimed at best facilitating an effective IFR survey.

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Objective

The objective of this guideline is to provide a comprehensive "step by step" methodology for evaluating Indoor Firing Ranges (IFR) within the Department of National Defence (DND).

It is intended for use by Preventive Medicine Technician's (PMed Techs) who are aware of Industrial Hygiene techniques: specifically those trained in the use and handling of air sampling pumps; velometers; calibrators; and, the general concepts of conducting an Indoor Firing Range survey. It is also intended as a "general" guideline for users and maintainers as an aid in understanding the process and the decision-making (consultation with PMed Techs).

This guideline provides an inspection framework from a practical point of view with interactive theory and practical applications aimed at best facilitating an effective IFR survey.

Introduction

Indoor Firing Ranges (IFR) within DND are typically used by Canadian Forces (CF) personnel, Cadets, RCMP, and civilian organizations for firing small bore weapons in support of both operational/occupational and recreational requirements. They offer certain advantages over outdoor ranges in that there is year round availability and protection under controlled environmental conditions. However, because indoor ranges are an enclosed space, environmental control measures must be in place to ensure that contaminants generated during weapons' firing are kept within acceptable exposure limits (1).

The contaminant of most concern when firing a weapon in an enclosed space is lead. During firing, the primer compound in a round (containing such lead compounds as lead styphinate and lead peroxide) ignites and vaporizes, causing the round to propel through the barrel. The hot combustion gases produced, cause vaporization of the lead at the base of the projectile and additional lead is physically chaffed off as the round passes down the barrel. Further lead is released into the atmosphere during fragmentation and splattering of the lead round as it strikes the backstop (2). All of these mechanisms contribute to the presence of airborne lead and exposure.

Lead is not the only contaminant found during weapons' firing. Smaller quantities of Carbon Monoxide (CO), Sulfur Dioxide (SO_2), Oxides of Nitrogen (NO_x) and Ammonia (NH_3) are also generated (3), but it is the presence of inorganic aerosolized lead which causes the major respiratory health concern. Exposures to high levels or prolonged absorption of lead or its organic compounds, whether from inhalation of fumes and dust, or through ingestion, can cause significant medical problems. Damage to nerve tissues; inhibition of important enzyme systems; gastro-intestinal disturbances; anemia; and, a host of other serious symptoms can result from excess lead exposures.

Thus, it is important to ensure that lead exposures are kept **As Low As Reasonably Achievable** (ALARA) through the consistent, thorough evaluation of all aspects of an IFR. Assessment of the potential lead exposure, within an IFR, requires an evaluation of the current cleaning procedures, sanitation practices of users, assessment of IFR ventilation, air monitoring of lead concentrations, and monitoring of blood lead levels of personnel when required (4). It should also be noted that Indoor Firing Ranges should only be used for their intended purpose i.e. weapons' firing, and not for any other purpose such as a classroom or storage area. Although noise can be another significant health hazard in an IFR, it is not discussed in this guideline. The monitoring of noise levels, however, and the availability and use of hearing protection devices, should not be ignored and their importance cannot be overemphasized.

This guideline was not intended to be all encompassing and cover every aspect of occupational health and safety. It is, however, intended to assist the PMed Tech to perform an IFR survey from the onset to its completion.

For ease of use, this document has been written in a sequential phase format, with each phase interdependent on the other. The contents of each phase identify pertinent inspection requirements and the DND/CF policy guidelines (5) necessary for the completion of an accurate and detailed IFR survey.

Phase 1

Preliminary Range Information

In order to adequately prepare for an IFR survey, a review of all range documentation should be performed. This will provide the PMed Tech with essential information to enable them to identify previous incidences of non-compliance and indications of potential health and safety risks.

Recommended review items include:

a) past range reports (Base & Command PMed reports);
b) ventilation & floor plan schematics (Construction Engineers (CE));
c) building range maintenance, including CE work orders;
d) range firing register (available at range);
e) range license status (Range Safety/B Ops O/BTSO); and,
f) any safety reports.

Current Range Information

To obtain current information regarding the range and its operation, it is most efficient to contact range user(s) directly. The following lists, under each category, represent a sample of typical questions that should be asked and the type of information which should be gathered. This is by no means a full and complete list of questions and information that apply to all facilities, and you should apply your knowledge and experience to "customize" your questions, as appropriate, to obtain as complete a record of current range information as possible. A review of past reports and IFR documentation should guide you in determining additional information that needs to be obtained.

- is this range licensed, if so by whom, for what use, and date of licensing;
- are Standard Operating Procedures (SOPs) posted;
- who uses the range;
- when and how often does each group use the range;
- who controls the range;
- what type of butts does this range have;
- who is the contact person with a complete knowledge of the range;
- what type of weapons are fired; and,
- how many rounds for each weapon type are fired.

Range Safety Officers (RSO's)

Identify the RSO's and estimate both the frequency and duration of their exposures. Typically it is the RSO who has the highest potential exposure. If this is the case, and documentation is obtainable, then it is advisable to review previous blood lead reports on these individuals. Also, to appropriately determine the risk of the RSO in an IFR it is important to determine if there are any other potential sources of lead exposure (e.g. occupational (welding), hobby (ceramics)).

Ventilation

- is there a dedicated incoming and outgoing mechanical ventilation system in the IFR;
- does the mechanical supply ventilation system function;
- does the mechanical exhaust ventilation system function;
- are the electrical controls to the two separate mechanical ventilation systems interlocked;
- when were the ventilation systems last cleaned;
- when was the last maintenance of the ventilation systems completed;
- has the ventilation system ever failed (if yes, when & why);
- is the exhaust system filtered (HEPA filters); and,
- are filters handled as hazardous waste.

Cleaning

- are cleaning procedures posted and are they current;
- who cleans the range;
- when and how often is it cleaned;
- how is the range cleaned, e.g. wet mopping, HEPA vacuumed;
- what cleaning equipment is available;
- what personal protective equipment (PPE) is available for the cleaner;
- what is the frequency and procedure for cleaning the ventilation system; and,
- how often are the butts cleaned/repaired or replaced.

Monitoring

- has air monitoring been conducted previously and if so, when; and,
- have any exposed personnel required blood lead analysis.

Phase 2

Initial Inspection

The initial inspection of an IFR is a critical one. The inspection will proceed much more smoothly and efficiently, and all questions and concerns can be addressed and verified if it is performed with an inspection team consisting of field experts, a CE representative and a Range Safety representative.

The initial inspection of the IFR should begin with a view of the facility exterior, noting the mechanical intake and output ventilation positions. Also, observe adjacent facilities and their exhaust ducts to check on the possibility that airdischarged from businesses such as autobody shops, for example, could be drawn in by the range air intake ducts.

An initial inspection of the interior of the IFR is also required. So that specific details do not have to be recalled from memory later, it is suggested that a schematic drawing of the interior of the range be created. This drawing will constitute part of the inspection report and

will act as a future reference. Therefore, the diagram must be accurate and detailed. It should show all range measurements; sampling points; the ventilation system and its controls; lighting; and, any irregularities or obstructions. At this time it is also appropriate to observe and report on cleanliness of the facility.

Initial Ventilation Assessment

If, upon initial assessment, it is noted that a ventilation system is not present, discontinue the survey as per the Decision Matrix (Annex A). If a complete ventilation system is present (intake & exhaust) and the system appears to be functional, then begin initial testing of the ventilation system using smoke tubes:

a) at source air intake;

b) at each incoming/outgoing ventilation duct, verify that airflow removes contaminants from the shooter and RSO positions; and

c) test airflow at various points along the firing line and mid-range to determine if there is down-range laminar airflow.

While testing the ventilation and circulation within the IFR observe for any indications of turbulence or eddy formation (note on diagram), and ensure that there is no recirculation of exhausted air into the range.

Detailed Ventilation Assessment

Once the initial ventilation assessment is completed a detailed assessment of the IFR ventilation system should be performed. This is achieved by completing:

a) cross sectional readings to ascertain the general air flow and direction across a given point;

b) a determination of the total supply and exhaust air volumes. Note: Exhaust air should exceed Supply air by approximately 10%, creating a slightly negative pressure (6). A negative pressure ensures contaminants do not escape to adjacent range areas; and

c) a measure of static pressures of intake and exhaust ducts. Note: Static pressure measurements can be helpful for future reference and subsequent inspections.

Cross Sectional Readings

Using an air velometer, determine the air velocity at the firing line. This is conducted by dividing the cross sectional area of the room into equal centers (9) and recording readings at the center of each location. It is suggested that readings be assessed using 4 foot (ft) centers as a maximum, however, greater accuracy may be achieved by decreasing the distance between centers. To determine down range air velocity, average the sum of the total results.

Recommended Cross Sectional Air Velocities (6).

Firing Line	Feet per minute (fpm)	Meters per minute m/s
Maximum	100	0.51
Optimal	75	0.38
Minimum	50	0.25
Butts		
*Absolute minimum	35	0.18

*Note: Minimum downrange conveying velocity at the butts ensures that particulates are carried downrange and do not settle out prior to reaching exhaust duct above or behind bullet trap. Absolute minimum value is not to be used as a standard for firing point air velocity.

Total Supply/Total Exhaust

To determine total supply and exhaust air volumes, air velocity readings are taken at each supply and exhaust duct individually using a velometer. Velocity readings (location and number) will vary depending on the duct type, size and cross sectional area.

Traverse points for square or rectangular ducts normally total between 16 and 64 equal areas, not more than six inches apart.

For round ducts, six inches and smaller, at least six traverse points should be used. For round ducts larger than six inches, use at least ten or more traverse points. The greater the number of readings, the greater the accuracy of the averaged velocity.

To obtain the total volume of airflow within the duct, use the formula **Q = VA**.

Where **Q = Volumetric Flow Rate (Cubic feet per minute, CFM)**
V = Average Velocity, (fpm)
A = Cross sectional area of duct or hood at measurement location (ft^2)

To obtain the total supply air volume, average all the individual supply air duct results. The same formula will apply to the exhaust system. At this point the total supply air volume and exhaust air volume can be compared to determine if the required negative pressure exists.

Sample calculation: ***Effective ventilation system***

An IFR has an exhaust and supply ventilation opening measuring 3 ft by 4 ft. To accurately determine the average velocity, 35 equally spaced readings have been taken and averaged. Once the average velocity and cross sectional area are known they are put into the formula, Q=VA, to determine the flow rate.

Supply Ventilation	Exhaust Ventilation
V = 48 fpm	V = 54 fpm
A = 12 ft^2	A = 12 ft^2
Q = 576 CFM	Q = 648 CFM

To determine if an adequate negative pressure exists in the range, compare exhaust and supply flow rates.

$$\frac{\text{Exhaust}}{\text{Supply}} = \frac{X}{100} \qquad \frac{648}{576} = \frac{112.5}{100} = 12.5\ \%$$

As exhaust flow rate exceeds supply by 12.5 %, a slight negative pressure exists in the range, and the ventilation system can be considered effective.

Sample Calculation: ***Ineffective ventilation system***

If on the next inspection of the same IFR you found that the supply flow rate had not changed but the exhaust had dropped.

Supply Ventilation	Exhaust Ventilation
V = 48 fpm	V = 47 fpm
A = 12 ft^2	A = 12 ft^2
Q = 576 CFM	Q = 563 CFM

Your calculation to determine ventilation adequacy would show that the IFR was not under negative pressure, but actually under a slight positive pressure.

$$\frac{\text{Exhaust}}{\text{Supply}} = \frac{X}{100} \qquad \frac{563}{576} = \frac{98}{100} = -2\ \%$$

These results would indicate that the ventilation system can be considered ineffective.

If the ventilation system functions well, a simple check of the Static Pressure (SP) on the next inspection will eliminate the need to repeat detailed measurements, providing, SP remains the same and airflow /smoke testing appears normal.

Static Pressure Measurement

Static Pressure (SP) measurements are recorded with the use of an Air Velocity Meter, (most commonly an Alnor) or an inclined manometer, expressed in inches of H_2O. The location of the SP opening is generally not too important in obtaining a correct measurement, however elbows in ducting should be avoided, or any other location where the air velocity is not parallel with the duct wall (9,10).

Accurate measurement of SP normally requires 2 to 4 holes be drilled, at uniform distances around the circumference of the duct to obtain an average and to detect any discrepancies in the values. The opening should be flush with the inner surface of the duct wall, and there should be no burrs or projections on the interior surface. Thus, the holes

should be drilled, not punched. Upon completion of SP readings it is advisable to cover the holes.

Generally, the minimum opening required when using a SP probe (Alnor) is 5/8". The probe should be placed carefully over the opening in the wall of the duct ensuring that a positive seal is made at the edges of the rubber cup.

If it is determined that the ventilation system is functioning properly, then progress to the next Phase (Air Sampling). If not, as per the Decision Matrix, recommend closure and ventilation system modifications.

Based upon the information gathered in steps I, 2 and 3, an initial survey report should be submitted to the responsible authority. This report will include results of the combined ventilation and smoke tube assessment, as per the Decision Matrix. The results found in the initial survey and the recommendations made will determine whether there is a requirement for further testing of the IFR.

Phase 3

Air Sampling

The purpose of performing air sampling in an IFR is to determine the concentration of lead dust and/or fumes in the air, as inhalation is the primary route of entry into the body. This is accomplished by performing area sampling (inside and outside the range) and personal sampling (representative range users) using air sample pumps with the appropriate sampling train. The actual exposure to lead can be determined by measuring a known quantity of air over a known period of time. Once exposure concentrations are determined, a judgment of the range conditions can then be made by comparing the results against a known and recognized standard (1).

The decision for the number of personnel who should be sampled should be based upon the typical number of most exposed users who use the range at any one time, remembering to sample the RSO and a representation of shooters. When choosing the total sampling time ensure that the worst case exposure, to which the range is intended to be licensed, is measured.

Sample Locations

Personal Sampling

Personal sampling is carried out to ascertain the level of lead dust/fumes present in the breathing zone of the range users. To accomplish this, air sampling pumps with the appropriate sampling train are attached to selected individuals and the sampling cassette is positioned as close as reasonably possible to the breathing zone. It is not necessary that each shooter be monitored, however enough samples must be taken to represent the exposure to all individuals, (i.e. two of four, three of six shooters' etc, may be monitored). Persons to be sampled include;

a) One RSO's position; and

b) A good representation of shooter's should be sampled (i.e. 2 of 4, 3 of 6).

An example of positions to be sampled can be found at Annex B.

Area Sampling

The purpose of performing area sampling is to confirm ventilation. These results should not be applied against the Threshold Limit Value/ Time Weighted Average (TLV/TWA) for personal exposures.

It is suggested that a minimum of two background samples be collected prior to the commencement of firing, one sample located at the butt area, the other at the firing line. These background samples will determine the level of ambient airborne lead, prior to weapons firing and determine the effectiveness of the ventilation system and range cleanliness. Each sample should be collected according to the NIOSH * method # S341, at a flow rate of 1.5 l/min. and a minimum total volume of 180 liter's (7).

* Although this guideline mentions the NIOSH standards, many Canadian laboratories utilize other standards. It is recommended that each PMed Tech liaise with the laboratory that will perform the analysis to ensure that appropriate methods and flow rates are followed.

During active firing, one area sample should be taken behind the firing line to measure any airborne lead which may migrate backward of the firing line and settle as dust. One sample should also be taken in an area adjacent to the IFR, (i.e. hallway, storeroom, office) to determine that there is adequate negative pressure in the range and to assess the extent of any lead migration. Both area samples will assist in determining the performance of the ventilation system.

In summary, to properly assess air quality for lead in an indoor firing range it is suggested that sampling be conducted in the following locations (Annex B):

a) One area sample behind firing line;

b) One adjacent area sample;

c) One sample at the Butt area; and

d) One mid-range sample, if the number of pumps allow.

Sampling Equipment

To assess the airborne lead concentrations, samples are collected with the use of personal monitoring air sampling pumps, connected to a filter cassette assembly. Cassette filters will normally be supplied from a laboratory pre-weighed, assembled and sealed with a cellulose band. The 3 piece filter cassette assembly should contain a 37 mm diameter cellulose ester filter with a 0.8 micrometer (μm) pore size and a 37 mm filter pad. According to NIOSH method S341 (7) sampling should be conducted with a closed face sample cassette, with inlet and outlet plugs removed, and sampling train attached. In order for the laboratory to accurately determine the concentration of lead, it is necessary to record the actual flow rate and time sampled.

Accurate determinations of flow rates requires that all sampling pumps be calibrated, with the complete sampling train in line, on site, using a primary calibrator pre- and post-survey. Pre- and post-calibration assures a constant and accurate volume of air was sampled during the survey, the acceptable deviation is +/- 5 %. The addition of a cassette after calibration will add resistance and result in erroneous volumetric readings. If available, an additional pump should be on hand to act as a back up in case of mechanical failure.

On completion of the survey, all samples for inorganic lead must be sealed by replacing the cassette plugs, labeling the cassettes and forwarding them to an accredited analytical laboratory. Results are normally returned as concentration of lead in micrograms per filter unit. However, requests can be made to the analytical laboratory to supply the results in milligrams of lead per cubic meter of air (mg/m^3). In order for the laboratory to perform this calculation, the laboratory must be supplied with total sample time and the total air volume for the results to be calculated as mg/m^3. These results can then be used to calculate the 8-hour TLV/TWA to determine actual lead exposure (1). The CF TLV/TWA is 0.05 mg/m^3.

TLV/TWA

TLV/TWA is defined as the average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day without adverse effect. Thus, to determine if an individual is at risk and their exposure exceeds the TLV/TWA, lead exposures should be time weighted over an eight-hour day.

To compare a mg/m^3 result obtained from the IFR survey to the TLV/TWA standard, the following formula must be incorporated;

$$\frac{(C_1T_1)+(C_2T_2)+(C_3T_3)}{(480)} = X\ \frac{mg/m^3}{(480)} = X\ mg/m^3$$

C = laboratory result in mg/m^3;
T = total time of individual samples; and
Equation denominator can be in hours or minutes as needed.

Sample Calculation (Shooter): Assume that during an IFR survey a personal sample is taken on a shooter. Sample time was 45 minutes of active firing on the range. On completion of firing, the shooter left the range and no further exposure (435 min) occurred. The sample result was 1.5 mg/m^3. Using the above formula the result can be compared to the TLV/TWA standard as follows:

$$\frac{(C_1T_1)+(C_2T_2)}{(480)} = \frac{(1.5\ mg/m^3 \times 45\ min.)+(0 \times 435\ min.)}{(480)} = \frac{67.5\ mg/m^3}{(480)} = 0.14\ mg/m^3$$

It is therefore determined that this sample is above the TLV/TWA standard of 0.05 mg/m^3.

Since the TLV/TWA has been exceeded, the ultimate recommendation will be to close the range. It is feasible that operational commitments will not allow the range to be closed. Thus, as an interim measure until improvements can be made, an effort must be made to reduce exposure. Reducing the time that an individual is exposed to lead will ensure that exposure remains within the TLV/TWA standards. Using the above example parameters, an example of time reduction to obtain a result within TLV/TWA standards is provided below:

$$\frac{(1.5\ mg/m^3 \times 15^*\ min.) + (0 \times 465\ min.)}{(480)} = \frac{22.5 mg/m^3}{(480)} = 0.05\ mg/m^3$$

*** Exposure time has been reduced to 15 min.**

Sample calculation (RSO): Assume that during an IFR survey a personal sample is taken on a RSO. Sample time was 240 minutes of active firing on the range. The sample result was 0.1 mg/m^3. Using the above formula this result could then be compared to the TLV/TWA standard as follows:

$$\frac{(C_1T_1)+(C_2T_2)}{(480)} = \frac{(0.1\ mg/m^3 \times 240\ min.)+(0 \times 240\ min.)}{(480)} = \frac{24\ mg/m^3}{(480)} = 0.05\ mg/m^3$$

It is therefore determined that this sample does not exceed the TLV/TWA standard of 0.05 mg/m^3.

Sample Calculations / Averaging

As defined by ACGIH (1), TLV/TWA is the average concentration over a normal 8 hr day to which nearly **all** workers may be repeatedly exposed. Thus, when calculating TLV/TWA to determine compliance of an IFR it is appropriate that the results obtained from all shooters should be averaged. Using this method, even if one or two shooters have individually exceeded the standard, the averaged result could still be lower than the CF TLV/TWA of 0.05 mg/m^3. If a situation occurs in which a single sample exceeds the TLV/TWA or does not appear to represent a normal exposure, a thorough investigation of possible causes (unbalanced ventilation, airflow obstruction, obstruction at shooters position, or other conditions) must be undertaken. If this elevated exposure(s) has been found to be unexplained in a well-functioning range, then this reading should be used in the overall average. If this elevated exposure(s) has been caused by some type of explained range deficiency, the reading may be discarded from the overall average and corrective action must be undertaken.

Air sampling data gathered from the RSO's position cannot be averaged with the results of the shooters, and must stand alone. Data gathered from the RSO's position may vary widely from those of the shooters as the conditions are not the same and cannot be compared.

Biological Monitoring

To truly evaluate lead exposure to individuals, it is necessary not only to determine potential lead exposure as determined from environmental monitoring measures, but the actual uptake or body burden. Biological monitoring is intended to measure the lead accumulation in persons most exposed (RSO's and frequent shooters). The risk factors which should be considered when determining if biological monitoring is necessary include: increased frequency of use; larger caliber of rounds; weapon rate of fire; other lead exposure; and, marginal or absent ventilation system.

The maximum allowable blood lead level is 50 mg/dl, with the exception of pregnant females, which is 40 mg/dl. A blood lead surveillance program has been instituted to safeguard those individuals who are in a high-risk group. The biological monitoring program, as detailed in CFMO 40-05, requiring periodic blood testing, has been instituted to observe high-risk group individuals (RSO's, frequent shooters and pregnant females).

Final Report

On conclusion of the survey, all data gathered must then be compiled, analyzed and interpreted. This information forms the basis of a written report that will convey all results and recommendations with regard to all surveyed aspects of the range. The combined results of all portions of the survey (ventilation, air sampling, biological monitoring and general housekeeping) play a key role in determining the fitness of the range facility.

It is important to remember that a recommendation of reduced exposure does not preclude administrative controls. It should also be made clear that the Medical Services Branch does not have the authority to act on recommendations, we only provide recommendations to the operational community on the use and or rehabilitation of ranges. It is up to the operator to weigh the risk of exposures with the importance of the operational or training use and the cost of rehabilitating the range. Reasons to use administrative controls, to limit exposure to rehabilitate, or to close the facility are the responsibility of the operational authority.

Acknowledgement

I would like to thank all of the PMed techs who have contributed to the contents of this guideline (of which there are to many to mention), without them this working guideline would not have had a true hands-on perspective, nor would it have mentioned all of the precautions and problems that all Pmed techs have dealt with at one time or another in their careers. Thankyou.

Annex A
dated Jan-99

Decision Matrix

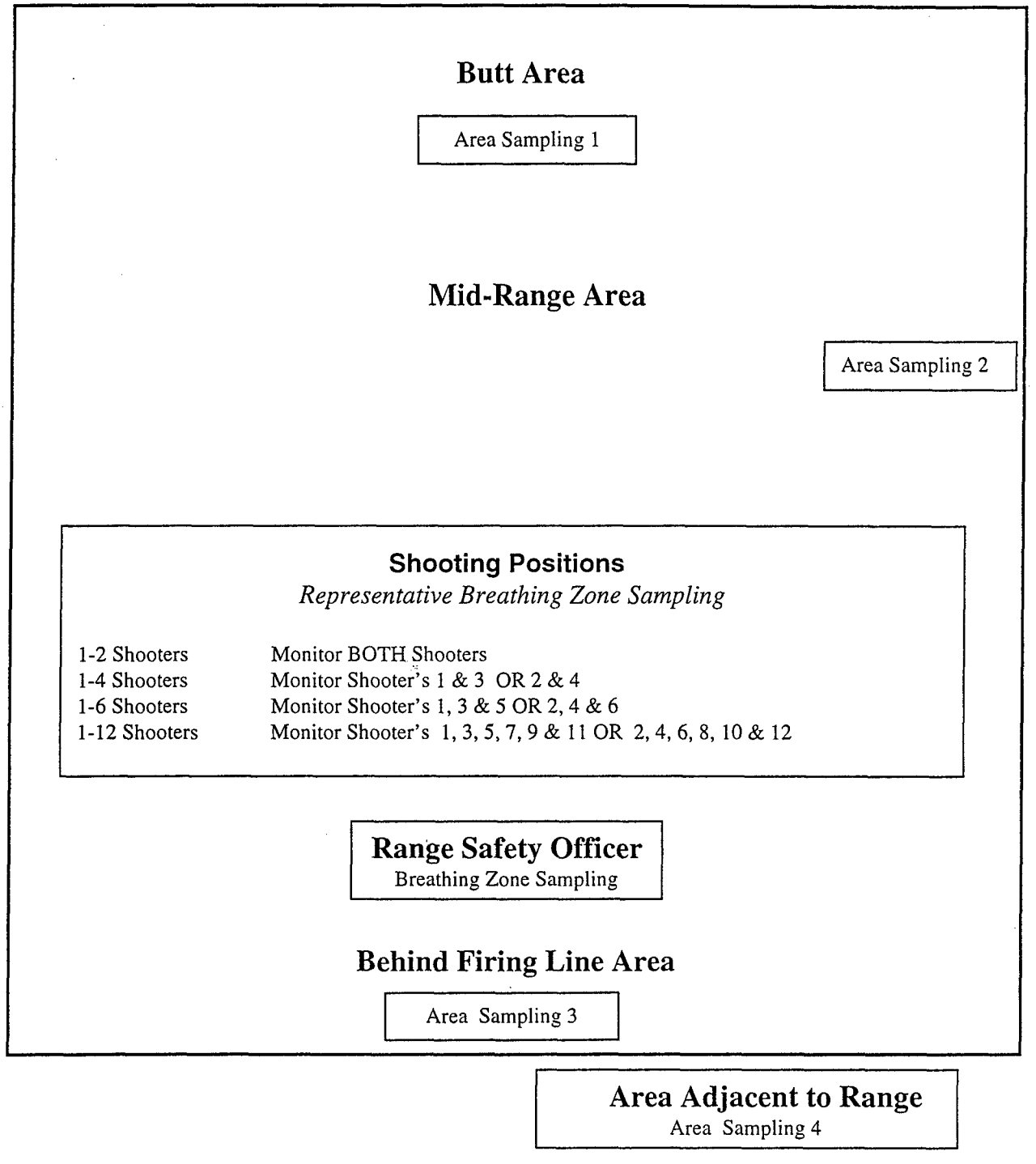
TESTING DONE	RESULTS	RECOMMENDATION
Ventilation assessment Lead - airborne - blood	- Within limits - Within limits - Within limits	Re-inspect on an annual basis
Ventilation assessment Lead - airborne - blood	- Inadequate - Within limits - Within limits	Implement Engineering & Maintainance Remedial Measures Re-inspect IFR at 6 month intervals, as required
Ventilation assessment Lead - airborne *- blood	- Inadequate - Elevated * Elevated	Immediate Range Closure, pending implementation of Engineering & Maintainance Remedial Measures If range must remain open, users and cleaners will require PPE to reduce exposure Re-inspect range at 3 month intervals until Ventilation status is acceptable
Ventilation assessment	-Absent or non-functioning	Immediate Range Closure, pending implementation of Engineering & Maintainance Remedial Measures Re-inspect range at completion of Engineering & Maintainance Remedial Measures
Ventilation assessment	- Exhausts to non-range occupied area	Range not be used until ventilation system fixed. Implement Engineering & Maintainance Remedial Measures

Note: If closure and rehabilitation of the range are not possible or practical to operational commitments, interim measures may be appropriate (decreased exposure time, PPE, decrease caliber of weapons, etc.). Calculations are based on the assumption that all conditions remain exactly as they were during the survey

* Recommendations for closure are based on elevated blood levels and should be made only after other possible sources of lead exposure are ruled out (ceramics club, civilian gun clubs, etc.).

Annex B
dated Jan-99

Suggested Personal Breathing Zone and Area Sampling Point Locations



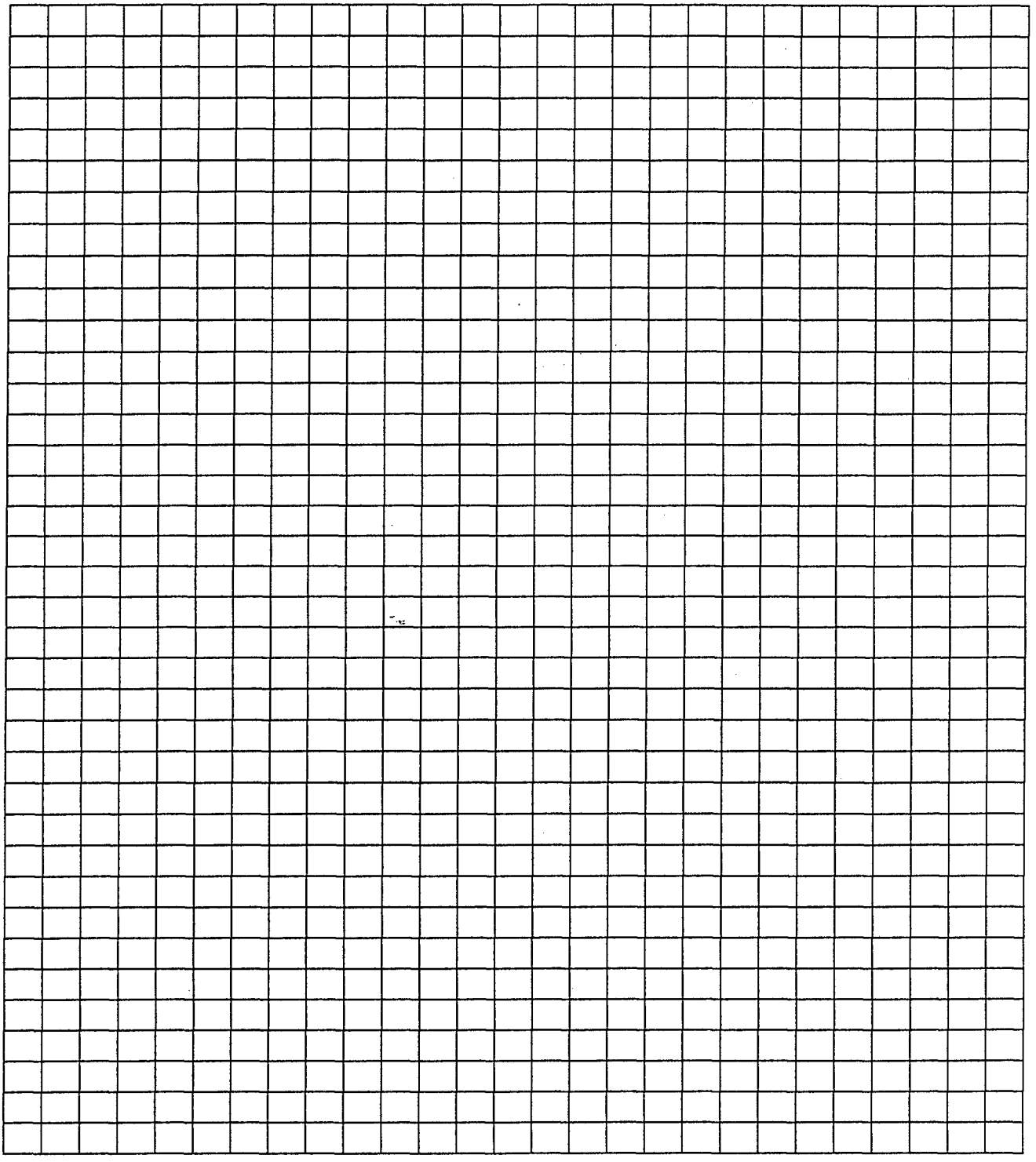
Annex C
dated Jan-99

List of Equipment

- Air velocity Meter complete with operating instructions
- Individual sampling pumps with chargers and operating instructions
- Flow Calibrator with operating instructions
- Filter cassettes
- Cellulose nitrate membranes (Cellulose Ester 37mm)
- Cellulose bands (MSA Part # 625415)
- Tygon tubing with hooks
- Smoke tube kit
- Stopwatch
- Marker
- Measuring tape
- Flashlight
- Extension cords
- Ear defenders
- Respirator with filters
- Blueprint of range Ventilation system
- Camera with flash
- Coveralls
- Hard-cover log book

Annex D
dated Jan-99

Range Diagram Worksheet



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10. Operating Instructions, For Alnor Series 6000-P Velometer
Alnor Instrument Company, 7301 Caldwell Ave, Niles Illinois 60648.

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Indoor Firing Ranges (IFR) within DND are typically used by Canadian Forces (CF) personnel, Cadets, RCMP, and civilian organizations for firing small bore weapons in support of both operational/occupational and recreational requirements. As indoor ranges are an enclosed space, environmental control measures must be in place to ensure that contaminants generated during weapons' firing are kept within acceptable exposure limits (1). The contaminant of most concern when firing a weapon in an enclosed space is lead. During firing, the primer compound in a round ignites and vaporizes, causing the round to propel through the barrel. The hot combustion gases produced, cause vaporization of the lead at the base of the projectile and additional lead is physically chaffed off as the round passes down the barrel. Further lead is released into the atmosphere during fragmentation and splattering of the lead round as it strikes the backstop (2). All of these mechanisms contribute to the presence of airborne lead and exposure. Lead is not the only contaminant found during weapons' firing. Smaller quantities of Carbon Monoxide (CO), Sulfur Dioxide (SO_2), Oxides of Nitrogen (NO_x) and Ammonia (NH_3) are also generated (3), but it is the presence of inorganic aerosolized lead which causes the major respiratory health concern. Thus, it is important to ensure that lead exposures are kept **As Low As Reasonably Achievable** (ALARA) through the consistent, thorough evaluation of all aspects of an IFR. Assessment of the potential lead exposure, within an IFR, requires an evaluation of the current cleaning procedures, sanitation practices of users, assessment of IFR ventilation, air monitoring of lead concentrations, and monitoring of blood lead levels of personnel when required (4). It should also be noted that Indoor Firing Ranges should only be used for their intended purpose i.e. weapons' firing, and not for any other purpose such as a classroom or storage area. Due to the potential health implications it is essential that inspections of IFR be complete. Thus, this guideline been written with the intention of providing a comprehensive "step by step" methodology for evaluating Indoor Firing Ranges (IFR) within the Department of National Defence (DND). It is intended for use by Preventive Medicine Technician's (PMed Techs) who are aware and comfortable with the principles and practices of Industrial Hygeine: specifically those trained in the use and handling of air sampling pumps; velometers; calibrators; and, the general concepts of conducting an Indoor Firing Range survey. It is also intended as a "general" guideline for users and maintainers as an aid in understanding the process and the decision-making (consultation with PMed Techs). This guideline provides an inspection framework from a practical point of view with interactive theory and practical applications aimed at best facilitating an effective IFR survey. It was not intended to be all encompassing and cover every aspect of occupational health and safety. It is, however, intended to assist the PMed Tech to perform an IFR survey from the onset to its completion. For ease of use, this document has been written in a sequential phase format, with each phase interdependent on the other. The contents of each phase identify pertinent inspection requirements and the DND/CF policy guidelines (5) necessary for the completion of an accurate and detailed IFR survey.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible, keywords should be selected from a published thesaurus, e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

IFR, Indoor Firing Range, Industrial Hygiene techniques, Industrial Hygiene assessment, Occupational Health assessment, monitoring, lead

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